Glacial Modification of Terrain

Chapter 19

Last Ice Age

- **The Pleistocene Epoch**
  - **Began- 2 million years ago- maybe ended 10,000 years ago**
- **Impact of glaciers on the landscape**
  - Form when year to year accumulation of snow is greater than the amount that melts during the summer
  - Have an overwhelming impact on the landscape
    - Moves everything in its path
    - About 7% of all contemporary erosion is done by glaciers
    - Modifies flat landscapes with post glacial slope, drainage, and superficial material

Glaciations Past and Present

- **Pleistocene Glaciation**
  - Boundaries unknown- may have started 1.8 million years ago or earlier
  - About 2.5 million years ago- there was an "amplitude" in climate fluctuations- causing some parts of the Northern Hemisphere to be covered by glaciers
  - Glaciologists are changing their thoughts that this epoch may be only 9000 years ago – whether this is a Glacial or interglacial period
  - End of the Pleistocene epoch in North America known as the "Wisconsin" glacial stage approximately 10,000 years ago
  - The period since then is known as the "Holocene" epoch. Could be either post glacial or an interglacial interlude
  - At maximum Pleistocene extent, ice covered one third of the total land area of Earth

Indirect Effects of Pleistocene Glaciation

- **Periglacial processes**- the erosion & deposition done by the prodigious amounts of melt water released as the glaciers melted
  - Frost weathering associated with solifluction of frozen subsoil
- **Sea-level Change -** more water stored in the ice – less water in the oceans – when glaciers melted ocean levels went up
- **Crustal depression** - enormous weight of accumulated ice on continents caused portions of Earth's crust to sink- When ice melted the crust would rebound- Isostatic adjustment in portions of Canada and Europe- They are still rising.
- **Pluvial (increased rain) developments**- during glaciation period. There was a considerable increase in precipitation, and a decrease in evaporation
  - Result 'pluvial effects' created many lakes where previously there had been none

    - Most have drained or significantly reduced in size but have left lasting imprint- example Lake Bonneville

Contemporary Glaciation

- **Compared to Pleistocene glaciation, the extent of ice covering the continent surfaces today is very small – 96% in Antarctica and Greenland**

Antarctic Ice Cap

- **98% of its surface covered by glacial ice- representing 85% of the world's land-ice**.
    - This ice is more than 13,000 feet think
    - Continent and its ice sheets can be thought of two unequal sections separated by Transantarctic Mountains
    - West Antarctica is general mountainous-contains the "Dry Valley" area which consists of about 1500 sq. miles, which, because the winds blast away snow & keep precipitation out; ice does not build up.
    - **The three major parallel valley's contain several large lakes, a number of ponds- and a river that runs 1 to 2 months a year**
    - **East Antarctica- extensive** – large broad plateau
    - **West Antarctica** - 8000 foot above sea level
    - **Greenland Ice Cap** – less extensive- 670,000 sq. miles

North American Glaciers

- In conterminous U. S., most glaciers are on the **Pacific Northwest and more than half of these are in the north Cascade Mountains of Washington**
- **In Alaska there are 75,000 sq. miles of glacial ice, amounting to about 4 percent of the total area of the state.**
    - The largest Alaskan glacier is the Bering Glacier, near Cordova, which covers 2250 sq, miles and is more than twice the size of Rhode Island.

Types of Glaciers

- **Continental Ice sheets**
    - Non-mountainous areas of **the continents**
    - During the Pleistocene Epoch-vast blankets of ice complete inundated the underlying terrain to the depths of hundreds or thousands of meters
    - Around the margins of the ice sheets, glaciers form.
    - Only exist in Greenland and Antarctica
- **Mountain Glaciers**
    - **Highland Icefields** – accumulations of unconfined sheet of ice covering a few hundred or few thousand of square kilometers.
    - **Valley glaciers** - outlet tongues of ice traveling down valleys out of the icefields
    - **Piedmont glacier** - the glacier that escapes the valley
    - **Alpine glaciers** – individual glaciers in mountain tops

        - **Cirque glaciers** form in basins of mountain tops

Glacier Formation and Movement

- **Glaciers require certain combination of temperature and moisture to survive circumstances to form and then depend on just the right**
- Need a balance between:
    - **Accumulation** of ice by incorporation of snow
    - **Ablation** – wastage of ice through melting and sublimation
- **Changing Snow to Ice**
    - Snow is changed to ice by compression and coalescence, following a sequence from snowflake to granular snow to neve to glacier ice
    - **Neve or firn** – compacted snow
    - **Glaciers divided into two portions**
        - **Accumulation zone** – upper portion where new ice is formed
        - **Ablation zone** – lower zone where ice is lost due to less snow
        - **Equilibrium line** – where accumulation and ablation are equal

Glacial Movement

- **The "flow" of a glacier involves an orderly sliding of ice molecules one over the other**
- **A flowing glacier is not necessarily an advancing glacier.**
    - **A glacier oozes outward from the edge of an ice sheet or down-valley from the toe of an alpine glacier.**
        - **Laminar flow** – internal planes which causes different portions to move with different speeds
        - **Basal slip** – movement at the bottom of the glacier on a film of water
- **Glacier Flow versus Glacier Advance**
    - Glaciers are always flowing, either outward or downhill
    - **BUT** glaciers are not always advancing depending on the balance between the accumulation and ablation.

Effects of Glaciers

- **Erosion by Glaciers**
    - **Glacial Plucking** – rock particles beneath the ice are grasped as meltwater refreezes in bedrock joints and fractures where frost refreezes in bedrock joints and fractures where frost wedging further loosens the rock.
    - **Glacial Abrasion** - Bedrock is worn down by rock debris being dragged along by moving ice

Transportation by Glaciers

- **Glaciers move immense amounts of rocks**
    - **Glacier Flour**- rock load ground very fine
    - Most material transported plucked or abraded from underlying surface

- Flowing water during the summer months help with the transportation of debris

Deposition by Glaciers

- **One of the important roles of glaciation is landscape modification**
- **Glaciers move material from one region to another**
    - **Drift** – general term for all material moved by glaciers
    - **Till** – rock debris deposited by moving or melting ice with no meltwater flow or redeposition involved
    - **Glacial Erratics** – outsized boulders are included in the glacial till

Deposition by Meltwater

- **Glacial runoff has several peculiarities**
    - Peak flows in midsummer
    - Distinct day-and-night different in volume
    - Large silt content
    - Occasional floods
- **Glaciafluvial deposition** - occurs around the margins of all glaciers

Continental Ice Sheets

- **Development -** in subpolar and mid latitude locations and then spread outward in all directions poleward
- **Initial Flow -** channeled by the preexisting terrain along valleys and other low-lying areas
- **Erosion by Ice Sheets**
    - **Ice sheets gently undulate the surface**
        - Notably produces a profusion of lakes
        - Roche Moutonee- Hills generally sheared off and rounded

Deposition by Ice Sheets

- **Till** is deposited heterogeneously and extensively without forming identifiable topographic features- a veneer of unsorted debris
- **Venee**r is sometimes quite shallow and does not mask the original topography call Till Plain
- **Moraine** – general term for glacial deposited landforms composed entirely or largely of till
- **Terminal Moraine**- a ridge of till that marks the outermost limit of the glacial advance
    - Formed when a glacier reaches equilibrium point and so it is wasting is at the same rate as it is nourished
- **Recessional Moraine** – the ridges that mark positions where the ice front was temporarily stabilized during the retreating glaciers

- **<u>Ground Moraine</u>** – large quantities of till laid down from underneath the glacier rather than from its edge
- **<u>Kettles</u>** – form when large blocks of ice left by retreating glaciers become surrounded or even covered by glacial drift – after the ice block melts, the morainal surface collapse leaving an irregular
- **<u>Drumlin</u>** – a elongated hill smaller than moraines but composed of similarly unsorted till.

Glaciafluvial Features

- **<u>Deposition or redeposition of debris by ice-sheet meltwater produces certain features</u>**.
  - **<u>Stratified drift</u>**-some sorting of the debris carried along by the meltwater
  - **<u>Outwash plains</u>** - smooth, flat alluvial aprons deposited beyond recessional or terminal moraines by streams issued from the ice.
  - **Valley train** – deposit of glaciafluvial alluvium confined to a valley bottom
  - **Eskers** – long sinuous ridges of stratified drift
  - **Kames** – small steep mounds or conical hills of stratified drift found sporadically in areas of ice-sheet deposition.
  - **Kame-and-kettle topography** - morainal surfaces containing a number of mounds and depressions

Mountain Glaciers

- <u>Most of the world's high mountain regions experienced extensive Pleistocene glaciation and many mountain glaciers exist today</u>
- <u>Effect of glacial action, particularly erosion, on mountainous topography is to create preglacial slope and relief</u>
- **<u>Development and Flow</u>** – Individual alpine glaciers usually form in sheltered depressions near the heads of stream valleys
- **<u>Erosion by Mountain Glaciers</u>**
  - **<u>In the High Country –</u>**
    - **<u>Cirque</u>** – a broad amphi-theater hollowed out at the head of a glacial valley
      - The first landform feature produced by alpine glaciation, essentially being quarried out of the mountainside
    - **<u>Arete</u>**- where several cirques have been cut back into an inter-fluve from opposite sides of a divide, a narrow, leaving a jagged serrated spine of rock, that may be all that is left of a ridge crest.
    - **<u>Col</u>** – the sharp-edged pass or saddle through the ridge that is being cut back by two adjacent cirques
    - **<u>Horn</u>** – a steep-sided, pyramidal rock pinnacle formed by expansive quarrying of the headwalls where three or more cirques interest.
    - **<u>Tarn</u>** – a depression formed to hold water after glacial ice in a cirque has melted away.

- **In the valleys**
    - A glacier moves down a mountain valley with much greater erosive effectiveness than a stream.
    - The principal erosive work of a valley glacier is to deepen, steepen, and widen its valley.
    - The cross-sectional profile is changed from a stream-cut "V" shape to an ice-eroded "U" shape called a Glacial Trough
    - Valley is straight because the glacier does not meander, but grinds away the protruding spurs that separate side canyons called Truncated Spurs
- **Glacial steps** – irregular parts that are gently sloping, flat, or steep, with some excavated depressions alternating in erratic sequence
- **Paternoster lakes** – shallow lakes
- **Hanging valleys** – tributary valleys are characteristically perched high along the sides of the major troughs.

Deposition of Mountain Glaciers

The principal depositional landforms associated with mountain glaciation are **moraines**.

Lateral moraines – well-defined ridges of unsorted debris built up along the sides of valley glaciers.

Medial moraine – a dark band of rocky debris

The Periglacial Environment

- **Periglacial** – the perimeter of glaciation
    - More than a 20% of the world's land area is presently periglacial, but most of this was covered by ice on one or more occasions during the Pleistocene epoch.
    - Most are found in the Northern Hemisphere because the Southern Hemisphere has less land.
- **Patterned Ground** – generic name applied to various geometric patterns that repeatedly appear over large areas.
- **Proglacial lakes** – where ice flows across a land surface, the natural drainage is either impeded or blocked, and meltwater from the ice can become impounded against the ice front

Causes of the Pleistocene

- **Why do we have Ice Ages?**
    - **The accumulation of ice masses more or less simultaneously at various latitudes in both hemispheres but without uniformity**
    - **The apparently concurrent development of pluvial conditions in drylands areas**

    - **Multiple cycles of ice advance and retreat, including both minor fluctuations over decades and centuries and major glaciations and deglaciations over tens of thousands of years**
    - **Eventual total deglaciation, either actual (past geologic era) or potential (for the Pleistocene epoch)**
- **<u>Are we still in an Ice Age?????</u>**